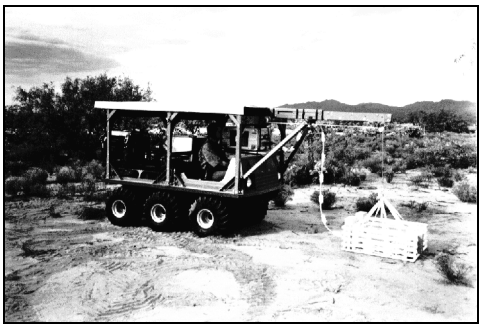
High-Resolution Subsurface Imaging & Neural Network Recognition

Developer: University of Arizona
Contract Number: DE-AC21-92MC29101
Crosscutting Area: CMST

Subsurface Contaminants FOCUS AREA

Problem:

Current ground-penetrating radar and electromagnetic (EM) techniques have limited depth of penetration in most soils. Non-invasive techniques that are cheaper, faster, and more accurate are needed to locate and identify contaminated subsurface features, including structures; trench or pit boundaries; and buried tanks, drums, pipes, and trash. Drilling for contamination detection and sampling is expensive, time consuming, and often dangerous.



Solution:

A continuous-profiling, high-resolution, high-frequency EM subsurface imaging system. The system is designed to 1) overcome the severe depth limitations of ground penetrating radar in conductive or clay-rich soil and 2) provide higher resolution and greater accuracy than conventional EM techniques.

Benefits:

- Faster non-intrusive means of mapping contaminated sites
- Field interpretation in near-real-time
- Reduced public & occupational health risks compared to usual geophysical surveys or drilling programs
- Faster interpretation permits cost-effective decisions and actions
- More accurate determination of the location and nature of buried objects.

Technology:

A high-frequency EM imaging system has been developed for the frequency range 30kHz to 30MHz. The system is an extension of an earlier imaging system which has a frequency range of 30Hz to 30kHz. The high-frequency extension is necessary to provide high resolution over the range of possible depths that are of interest on DOE projects. The system is designed to overcome the severe depth limitations of ground penetrating radar in conductive or clay-rich soil and to provide higher resolution and accuracy than conventional DC resistivity or EM induction techniques. The data collected will be interpreted in the field in near-real-time using neural networks. The network output will be the identification and location of subsurface targets. The high accuracy of the imaging system, coupled with the fast, accurate interpretation by the neural networks, will provide a faster non-intrusive means of mapping contaminated sites with less ambiguity. Tests of the accuracy of the existing low-frequency system and neural network interpretation indicated that a buried pipe could be located with 97% accuracy for horizontal position, 99% accuracy for depth and 94% accuracy for conductivity.

Current methods for interpreting EM data assumes simplified models of the earth, calculates theoretical EM fields for these models, and compares these to the observed EM

data. This is typically a slow and tedious process, involving much subjective guesswork by the interpreter in order to choose realistic models. This often takes many computer hours and is not well suited to exploiting the high-accuracy data from this system.

Newly developed neural network methods treat the data set as an image. This involves recognizing the patterns in the data, specifically, the earth-model pattern which corresponds to the observed data pattern. Neural networks perform well on the same types of tasks on which humans traditionally have performed well and on which Von Neumann computers have performed poorly, i.e., pattern recognition.

Abstraction and generalization are two properties neural networks possess. Abstraction is the ability to retain salient features of an input pattern and discard irrelevant ones. Generalization allows the network to recognize new inputs. A key feature of the continuous output network is its potential to produce results comparable to those from standard inversion routines. The network could potentially give information on location, size and conductivity in near-real-time mode instead of hours or days as required on a mainframe computer for conventional inversion. Unlike conventional inversion, neural networks retain their knowledge and continue to learn.

This project has four major activities and objectives: (1) develop a continuous-profiling, high-resolution, high-frequency EM subsurface imaging system featuring fast data acquisition, high spatial resolution, and high accuracy; (2) develop a neural network system that can interpret the data in near real-time with high accuracy and precision; (3) determine how tolerant the imaging system and neural network are to geologic and cultural noise contamination and (4) develop software for automated graphical display of field data.

Contacts:

The Department of Mining and Geological Engineering at the University of Arizona has been working with neural networks and their practical application in the resource development and environmental restoration areas. For information on this project, the contractor contact is:

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